Claims

1. A heat pump apparatus comprising

a compressor for compressing a refrigerant,

a radiator for cooling the refrigerant compressed by said compressor,

an expander for expanding the refrigerant which passed through said radiator,

an evaporator for vaporizing the refrigerant which is expanded by said expander,

a refrigerant pipe for circulating the refrigerant through said compressor, said radiator, said expander and said evaporator,

a pressure sensor disposed between said compressor and said expander for detecting pressure of the refrigerant,

a temperature sensor disposed between said compressor and said expander for detecting temperature of the refrigerant,

a permanent magnet type synchronization power generator connected to said expander,

a current sensor for detecting current which flows through said permanent magnet type synchronization power generator,

a first converter which converts AC power which is output from said permanent magnet type synchronization power generator into DC power, which estimates a magnetic pole position of said permanent magnet type synchronization power generator by a current value detected by said current sensor, and which controls the number of revolutions of said permanent magnet type synchronization power generator to a predetermined value by using the current value and the magnetic pole position, and

power generator revolution number controller for controlling said first converter by signals from said pressure sensor and said temperature sensor.

2. The heat pump apparatus according to claim 1, wherein said first converter estimates a magnetic pole position and the number of revolutions of said permanent magnet type synchronization power generator by a current value detected by said current sensor, and controls the current value and the number of revolutions of said permanent magnet type synchronization power generator to predetermined values by using the current value, the magnetic pole position and the number of revolutions.

3. The heat pump apparatus according to claim 1, further comprising

a second converter for converting AC of commercial power supply to DC, and

an inverter which connects DC output from said first and second converters to an input end of said inverter to convert the DC into AC having predetermined frequency, and which drives said compressor.

4. The heat pump apparatus according to claim 1, further comprising

a pressure sensor and a temperature sensor which are disposed between said compressor and said expander and which respectively detect pressure and temperature of said refrigerant, and

power generator current controller for controlling a current value of said power generator by signals from said pressure sensor and said temperature sensor such that the pressure of said refrigerant becomes optimal pressure.

5. The heat pump apparatus according to claim 1, further comprising

a pressure sensor and a temperature sensor which are disposed between said compressor and said expander and which respectively detect pressure and temperature of said refrigerant, and

power generator current controller for controlling an amount of generated electricity of said power generator by signals from said pressure sensor and said temperature sensor such that the pressure of said refrigerant becomes optimal pressure.

6. The heat pump apparatus according to claim 1, wherein when said expander is actuated, said power generator is driven in a power mode by said first converter.

7. The heat pump apparatus according to claim 1, wherein said power generator is operated by said first converter when a predetermined time is elapsed after said compressor is actuated.

8. The heat pump apparatus according to claim 1, wherein the refrigerant is carbon dioxide.

9. A power recovery apparatus comprising

an expander for expanding working fluid,

a permanent magnet type synchronization power generator connected to said expander,

a current sensor for detecting current which flows through said permanent magnet type synchronization power generator, and

a first converter which converts AC power which is output from said permanent magnet type synchronization power generator into DC power, which estimates a magnetic pole position of said permanent magnet type synchronization power generator by a current value detected by said current sensor, and which controls the number of revolutions of said permanent magnet type synchronization power generator to a predetermined value by using the current value and the magnetic pole position.